

CONSUMER ACCEPTANCE, TRUST AND FUTURE USE OF SELF-DRIVING VEHICLES

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Self-driving vehicles bring the promise of safer streets, reduced congestion, enhanced traffic flow, and greater mobility inclusion. But more information is needed to fully assess how they'll impact drivers, the economy, equity, the environment, and the overarching concern—safety.

According to the U.S. Department of Transportation, more than 1,400 self-driving cars, trucks, and other vehicles are currently in testing by more than 80 companies across 36 U.S. states and the District of Columbia (Etherington, 2019). Thus far, single-occupancy vehicles (traditional cars) are the prevailing mechanism

for autonomous technology experimentation although a number of cities are testing low-speed shuttles. Cities can derive educational value from the pilots, including information on the specific nature of the technology, its capabilities, operating challenges, and how the city's own typography impacts performance. Pilot cities get advanced knowledge and better understanding of the public's willingness to accept a self-driving vehicle presence and, in turn, can use the pilots to educate the public.

Seeking such benefits, in July 2018, Frisco, Texas, became the first city to pilot-test a self-driving shuttle service on public roads in Texas. The service launched by Drive.ai provided rides to employees of Hall Park, a large office campus in Frisco. Travelers could request a free ride using a Drive.ai app, and the vans would pick them up

In spring 2019, the Texas A&M Transportation Institute conducted an online survey of 840 Frisco residents (aged 18 years or older) including both Drive.ai pilot riders and non-riders. The survey respondents were recruited to participate through the Drive.ai app and also through outreach by the City of Frisco (*Frisco Focal Point Newsletter* and *Next Door*).

Generalizing from the Frisco survey findings to other geographical areas should be done with caution. A similar survey conducted in a different geographic context may result in significantly different findings.

The **median age** of the sample was **48**.

48% of respondents lived in households owning **two cars**, and **36%** had **three cars**.



97% drive almost every day.



Other transportation modes were not regularly used. In terms of public transit, **45% never use it**, and **45% ride it rarely**.

The majority of respondents were employed and lived in **households earning a total income of \$150,000 or more**.

Respondents' degrees earned: **37% post-bachelor's degree** and **42% bachelor's degree**.



52% lived in households with **no children**.



There are no regular users of ridehailing services. 35% are occasional users, 35% use ridehailing rarely, and most of the others never use ridehailing services.

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and drive them a short distance to nearby shops and restaurants. The pilot operated for eight months and served nearly 5,000 riders across 3,100 trips.

Initiatives such as the Drive.ai pilot in Frisco are important to monitor and track consumer acceptance, trust, and likely use of self-driving vehicles. An important transportation policy and planning question is: *In what ways will people change current travel and location choice behavior because of access to self-driving vehicles?* The answer to this question depends on how and by whom they will be adopted and used. Researchers at the Texas A&M Transporta-

tion Institute have been monitoring and tracking these issues for the past 5 years. They have documented the significant influence of demographic factors such as age (particularly for younger and older age segments) and having a mobility impairment; attitudinal factors such as data privacy concerns; behavioral factors such as being an early adopter of technology in general; new mobility services, such as ridehailing; and advanced driver assistance systems on their personal vehicles (Zmud et al., 2016; Zmud and Sener, 2017; Sener et al., 2019; Sener and Zmud, 2019).

The Drive.ai pilot in Frisco provided a chance to examine the influence of having taken a ride in a self-driving vehicle on acceptance, trust, and future use.

Knowledge, Awareness, and Experience

The vast majority of consumers in the survey, 98 percent, had heard of self-driving cars before taking the survey. This significant level of awareness is due to national media attention on self-driving vehicles, coupled with local media attention on the Drive.ai pilot, and the experiences of some persons riding in the Drive.ai vehicles. While people can imagine a world where cars drive themselves, they are less likely to realize that some of the automated features already in their car, represent levels on the way to the self-driving car of the future. Figure 1 depicts the difference among levels as prescribed by the Society of Automotive Engineers (SAE).

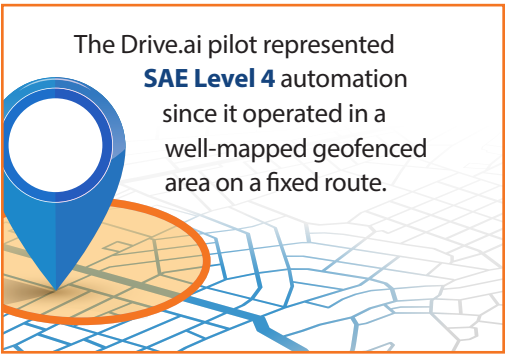




Figure 1. SAE Levels of Vehicle Automation

LEVEL	0 None	1 Assistance	2 Partial	3 Conditional	4 High	5 Full
What car does 	Nothing	Assists; accelerates, brakes, <u>or</u> steers	Assists; accelerates, brakes, <u>and</u> steers	Everything for short periods of time	Everything in a restricted operating environment	Everything
What driver does 	Everything	Everything with some assistance	Everything with more assistance	Remains alert and ready to resume control	Nothing in a restricted operating environment	Nothing

A video describing the levels of automated vehicle (AV) technology was embedded in the online survey to raise knowledge levels and increase the reliability of responses to subsequent questions that addressed attitudes and opinions relating to the different levels of automation in vehicles today and in the future. After the viewing the video, 54 percent of the survey respondents rated their level of understanding as “excellent” and 39 percent as “very good.”

The foundational level of knowledge could have been higher for this sample than for others. Many had experience with AV technology. About one in five respondents (18 percent) had taken a ride in a Level 4 or Level 5 self-driving vehicle (mostly in Frisco but also in some other cities such as Las Vegas and San Francisco) (Figure 2). A little more than half (53 percent) frequently use personally owned vehicles with advanced safety driver assistance features that can intervene in the driving of the vehicle, such as lane-keeping assist or automated-parking assist. These vehicles would be at an SAE Level 1 or 2.

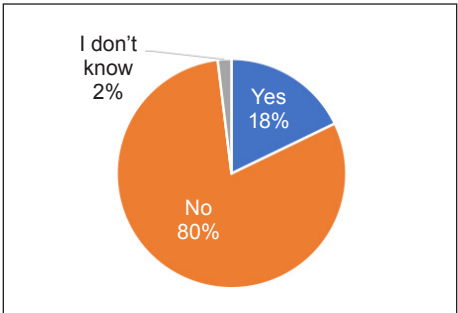


Figure 2. Have You Ever Taken a Ride in a Level 4 or 5 Self-Driving Vehicle?

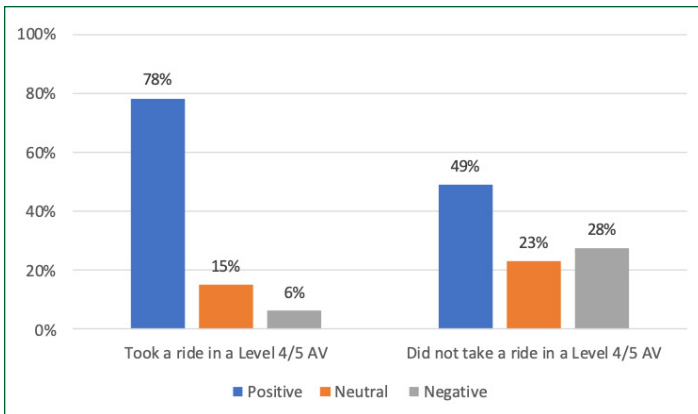


Figure 3. Opinion toward Level 4/5 Self-Driving Vehicle Technology by Experience of Riding in a Self-Driving Vehicle.

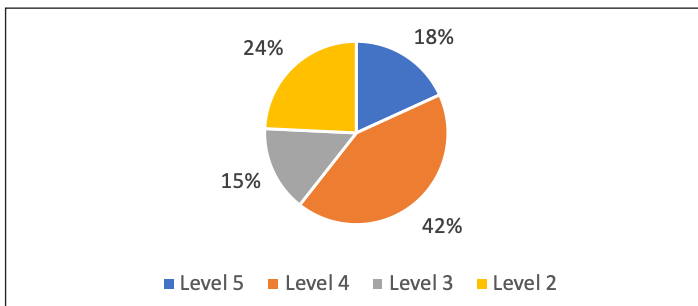


Figure 4. If Cost Was No Barrier and You Could Own a Vehicle with Any Level of Automated Technology within the Next Couple of Years, with What Level Would You Be Most Comfortable?

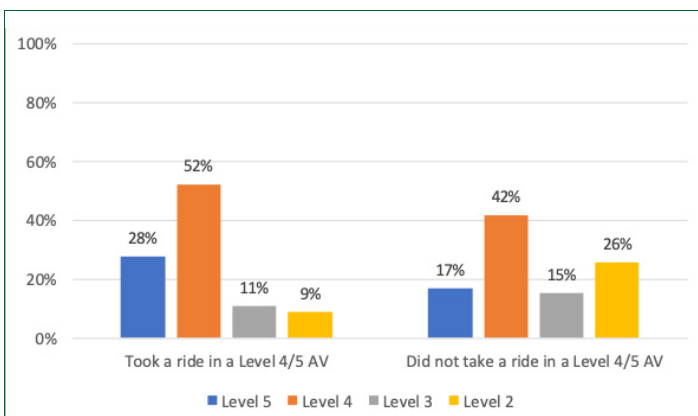


Figure 5. Preferences for Vehicle Automation Levels by Experience Riding in a Self-Driving Vehicle.

Acceptance, Preferences, and Opinions

The majority of sampled Frisco residents (54 percent) had a favorable opinion of self-driving technology. Of the remainder, 24 percent had a negative opinion, and 22 percent were neutral. The experience of riding in self-driving vehicle, like the Drive.ai pilot, had a positive effect. While 78 percent of respondents who have experienced self-driving vehicles had a positive opinion, the value dropped to 49 percent for people who have not experienced a Level 4 or 5 AV (Figure 3).

Acceptance of vehicles at higher levels of automation (Levels 4 and 5) was high in Frisco. Within the next couple of years, if cost were no barrier, 60 percent of respondents would prefer to own a vehicle at Level 4 (42 percent) or Level 5 (18 percent) (Figure 4). People preferred to own a Level 4 vehicle primarily because they did not fully trust the technology yet and wanted to be able to control the operation of the vehicle. Prior research also indicates that many people do not prefer (or accept) Level 5 vehicles yet because they understand that at this level the onboard computer system is totally in charge of the driving. People are not ready to cede that control to an autonomous vehicle.

Preferences to own a vehicle at Levels 4 and 5 were highest among young people (18–34 and 35–44 years of age), early adopters of technology, current users of ridehailing services, and those with advanced driver assistance systems in their personally owned vehicles now.

About one in four persons (24 percent) would prefer Level 2 vehicles. This is the highest level of automated technology that is in vehicles today. The smallest proportion of respondents would prefer to own a Level 3 vehicle (15 percent). At this level of automation, the vehicle controls the driving task for short periods of time, and the driver must remain alert to take over at any time. In prior studies, researchers have found that people think this takes away the main benefit of automated systems, which is to be able to do other things or zone out during driving.

A small proportion of people are ready to cede control of driving to a machine. In Frisco, this was nearly one in five people (18 percent). The most often cited reasons for preferring to own vehicles at Level 5 were trusting the technology, personal benefits (such as making travel less stressful, more relaxing, and fun), and societal

People who have experienced self-driving vehicles were also significantly more inclined to own a vehicle at the higher levels of automation than those who have not: Level 4 (52% vs. 42%) and Level 5 (28% vs. 17%) (Figure 5).



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benefits (such as increasing safety, reducing congestion, and reducing the need for parking).

People in the Frisco sample definitely are aware of the potential safety benefits of self-driving vehicles (Levels 4 and 5) (Figure 6). When asked about what level they trust most to reduce the likelihood of being in a crash, the ranked order by trust was Level 4 (39 percent), Level 5 (24 percent), Level 2 (21 percent), and Level 3 (15 percent):

- People most trusting Level 5 believe the technology would be fully tested to be safe, would best address human driving errors and distraction, and represents the most advance safety features.
- People most trusting Level 4 do not believe in the readiness of the Level 5 technology, and it is the next best thing in terms of advanced safety features.
- People most trusting Level 2 and Level 3 also do not believe in the technology readiness of higher levels of automation, and they are not psychologically ready for self-driving cars.

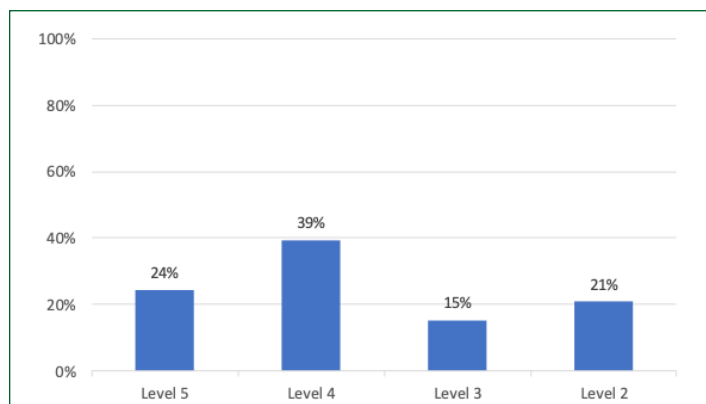


Figure 6. Assume All Levels of Vehicle Automation Are Operating on Public Roads Today; What Level of Vehicle Automation Would You Trust the Most to Reduce the Likelihood of Your Vehicle Being in a Crash?

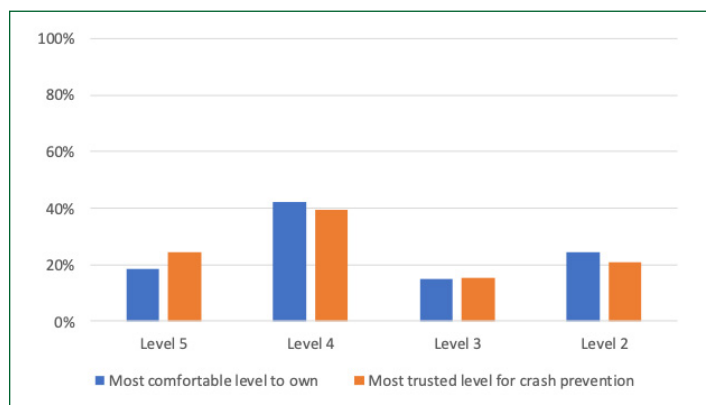


Figure 7. Preferred Level to Own versus Most Trusted Level to Reduce Likelihood of Being in a Crash.

The experience of riding in a Level 4 or 5 AV significantly reduces the fear of using a totally self-driving vehicle. **More than one-third (36 percent) of surveyed Frisco residents would be afraid to ride in a Level 5 self-driving vehicle.**

As noted in Figure 7, for most people, a Level 4 vehicle is both the preferred one to own in a few years and also the one most people trust to reduce the likelihood of being in a crash.

These consumer preferences regarding Level 4 vehicles is reflected in plans of major original equipment manufacturers. Many have announced plans to roll out Level 4 vehicles for ride-sharing applications and highway driving in the next 5 years (Walker, 2019).



The experience of riding in a Level 4 or 5 AV significantly reduces the fear of using a totally self-driving vehicle. More than one-third (36 percent) of surveyed Frisco residents would be afraid to ride in a Level 5 self-driving vehicle. But this percentage was reduced to 15 percent among those who had experienced a Level 4 or 5 AV (Figure 8). Three-fourths of them (76 percent) would not be afraid to ride in Level 5 self-driving vehicle compared to 41 percent of people who have not experienced a Level 4 or 5 AV.

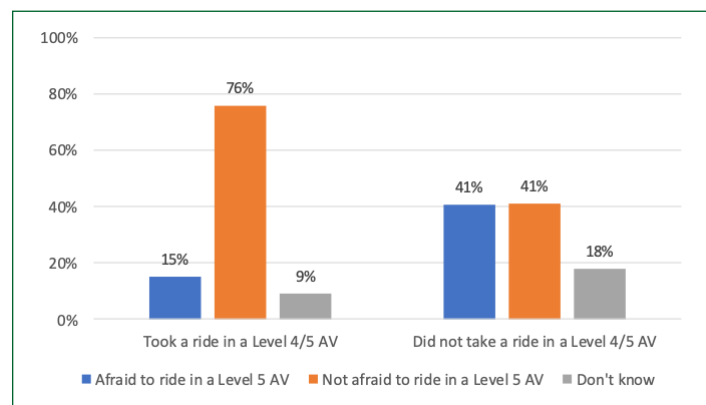


Figure 8. Would You Be Afraid to Ride in a Level 5 Self-Driving Vehicle?

Behavior with Regard to Level 5 Self-Driving Vehicles

When it comes to using Level 5 self-driving vehicles today, most Frisco residents would rather not own one (63 percent). Instead, they would prefer to use them as a low-speed shuttle, like the Drive.ai service (49 percent) or as a ridehailing service (48 percent) (Figure 9). This is interesting given the auto-dominant lives of Frisco residents. Virtually all persons who would prefer the ridehailing option would prefer to travel alone or with known traveling companions (78 percent) instead of using the ride-splitting or shared option.

People who chose the small, low-speed shuttle believed it would be the safest option (i.e., it travels slow and on a regular route), while ridehailing was selected by people who valued shared transport or who wanted to test a self-driving vehicle before buying. Purchasing a Level 5 self-driving vehicle was the choice of people who just prefer traveling in a personal vehicle. In general, these findings were similar regardless of individuals' experience with a Level 4 or 5 vehicle, with one additional interesting observation. For people who preferred to purchase a Level 5

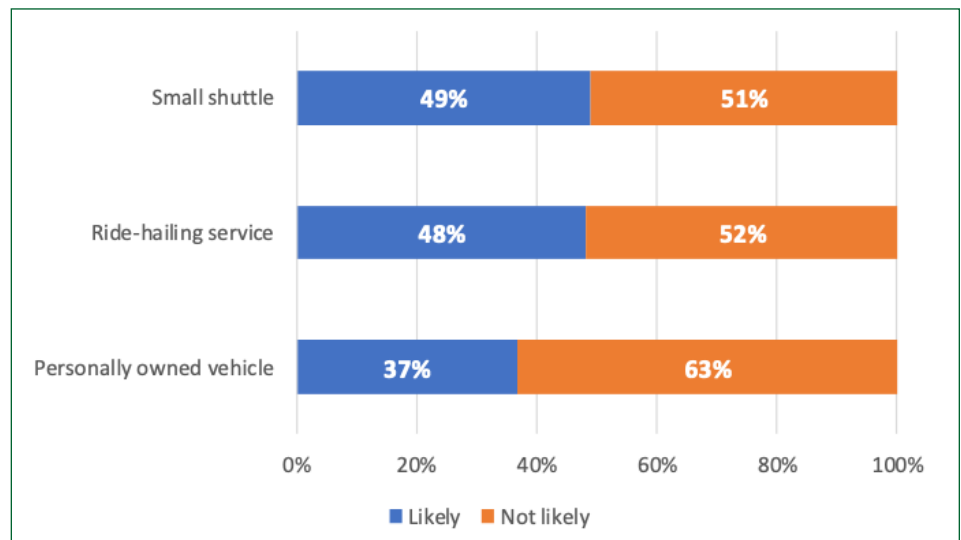


Figure 9. Imagine That Level 5 Self-Driving Vehicles (Always Self-Driving Anywhere) Were Available for You to Purchase and/or Use Today. How Likely Would You Be to Purchase a Level 5 Self-Driving Vehicle, Use Self-Driving Vehicles in the Form of a Ride-Hailing Service like Lyft or Uber, or Use Self-Driving Vehicles in the Form of a Small, Low-Speed Shuttle as On-Demand Transit.

self-driving vehicle, while just being interested in traveling in a personal vehicle was still the main reason, there were also a considerable number of people indicating they would like to purchase a self-driving vehicle because they just like this technology.

Overall Benefits and Concerns

Regardless of the type of self-driving vehicle that Frisco residents would use, their thoughts on the greatest benefit to them personally were the same: to have an improved travel experience (i.e., not have to pay attention; can do productive tasks; less stressful, more relaxing, and fun; and faster, more efficient, and less traffic). This benefit was cited much more frequently than having a safer travel experience. **On the other hand, when asked about the greatest benefit to society, safety was the most frequent response. This was especially true for those who preferred using self-driving personally owned vehicles or ridehailing vehicles.** Those who would use a self-driving vehicle as a low-speed shuttle also cited congestion, air quality, and mobility enhancement benefits.



The biggest overall concern is that the self-driving technology is so new. Frisco residents want to see them in action through pilot tests to trust that they are reliable and safe. There were also more limited concerns about the safety of self-driving vehicles in their interactions with non-AVs and with pedestrians and bicyclists, their capability for reacting safely to unforeseen circumstances (such as animals running into the road or road construction), and the uncertainty of what to do or whom to contact in emergency situations (such as a system outage).

Drive.ai Experience

A focus group was held with 15 persons who had taken a ride in the Drive.ai vehicle. Virtually all participants expressed positive opinions overall and believed that it enhanced the innovative image of Frisco. One person indicated that it was a selling point for hiring potential employees, especially those in the younger generation.

Most participants enjoyed the experience of riding in the vehicle but expected less human interaction from the safety driver during the trip. They expressed frustration that the vehicle was over-cautious at difficult intersections and would not proceed quickly enough through the intersection, that there were long wait times to be picked up by the vehicle, and that the vehicle did not appear more futuristic. All felt safe driving or walking on the same road as the vehicle mainly because it drove so timidly and followed the speed limit and other rules, which human drivers often do not. Overwhelmingly, the group supported the safety priority of Drive.ai. There was consensus that safety should come first and the technology and speed can always be improved later.

The project was designed as a service to get people to lunch places, etc. The group was asked if the service was what they had expected. The overwhelming response was that it would be nice if it could go to more destinations, including other places around Frisco. Seating capacity needed to be increased because it was cramped for three riders. The group overall was very supportive of future endeavors and



would like to see something similar in the future but with more vehicles and expanded service. The group was asked if they would prefer to own self-driving vehicle or to use an on-demand service such as Drive.ai.

The overwhelming response was that the participants would still want to own their cars because they did not want to give up their independence and freedom, but many were willing to use an on-demand service on an as-needed basis.

Conclusions

This research examined acceptance, concerns, potential usage, and factors influencing usage of self-driving vehicles among Frisco residents. Frisco residents were generally accepting of vehicles at higher levels of automation; there was greater acceptance of Level 4 because people are not ready to cede that control in a self-driving vehicle they might personally own. They would be more likely to use self-driving vehicles as small shuttles or as ridehailing vehicles. And, they would use these types of services occasionally for specialized purposes. Shuttles were viewed as the safest option at present because they are slow and travel in well-mapped geofenced areas. A main finding was that the experience of riding in a self-driving vehicle has a significant positive influence on residents' preferences, attitudes, and usage. It will be critical for cities to support autonomous vehicle pilots to get intelligence about their residents' thinking about self-driving vehicles for future policy and planning. In this study, researchers gathered information on residents' desires for benefits of self-driving vehicles and also their concerns. Opinions on main personal benefit (i.e., improved travel experience) differed significantly from the main societal benefits (i.e., safety). Their greatest concern was that the technology is new, and so they want to observe more pilot tests. In this light, planning for AVs should be considered an extension of planning for transportation in general.

Experience of riding in a self-driving vehicle had a significant positive influence on Frisco residents' preferences, attitudes, and potential usage. The biggest overall concern among residents was that the self-driving technology is so new. **Frisco residents want to see them in action through pilot tests to trust that they are reliable and safe.**



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